

the thickness of the panel as a whole and brings about an increase in weight thereof.

### SUMMARY OF THE INVENTION

Under these circumstances, it is an object of this invention to provide a plasma display panel which is sufficiently small in thickness to be easily packed, or otherwise handled.

It is another object of this invention to provide a process which can produce a plasma display panel easily, particularly after a sealed assembly of panel members has been completed.

It is still another object of this invention to provide a process which can produce a plasma display panel quickly at a low cost.

According to one aspect of this invention, there is provided a plasma display panel which comprises two parallel and spaced apart panel members joined to each other along the edges thereof by a sealing material forming a gas-tight seal therebetween, the panel members and the sealing material defining an enclosure filled with a discharge gas introduced therein through at least one port formed in one of the panel members, and a blocking member situated within the enclosure, joined to the other of the panel members, and closing the port in a gas-tight fashion.

The blocking member is situated between the two panel members and does not have any portion projecting outwardly from the panel. Therefore, the panel has a small thickness which is exactly equal to the sum of the thicknesses of the two panel members and the distance therebetween. Moreover, the blocking member contributes also to reinforcing the panel.

According to another aspect of this invention, there is provided a process for making a plasma display panel which comprises the steps of placing a first panel member and a second panel member in a parallel and spaced apart relation to each other, one of the panel members carrying along its edges a sealing material situated between the panel members and contacting the other of the panel members, so that the panel members and the sealing material may define an enclosure, while at least one blocking member which one of the panel members carries on its surface facing the inside of the enclosure is passed through at least one port extending through the other of the panel members and maintaining fluid communication between the inside and outside of the enclosure, evacuating the enclosure through the port, introducing a discharge gas into the enclosure through the port, and heating the whole, so that the sealing material may join the panel members along the edges thereof and form a gas-tight seal therebetween, while the blocking member closes the port in a gas-tight fashion.

This process makes it possible to assemble the panel quickly and at a low cost, since it accomplishes the joining of the two panel members and the closing of port simultaneously.

A modified form of the process is characterized by employing a blocking member having a height which is smaller than that of the sealing material, and which is larger than the prospective final distance between the two panel members. The blocking member faces the port when the enclosure is defined by the two panel members and the sealing material. After the enclosure has been evacuated and filled with a discharge gas, the whole is heated, so that the sealing material may join the panel members, and so that the blocking member may close the port simultaneously. The joined assembly of the panel members is easier to handle when the port is subsequently closed.

The above and further objects and novel features of the invention will more fully appear from the following detailed description when the same is read in connection with the accompanying drawing. It is to be expressly understood, however, that the drawings are for purpose of illustration only and are not intended as a definition of the invention.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a plan view illustrating a conventional plasma display panel;

FIGURE 2 is a sectional view taken along the line A-A of FIGURE 1;

FIGURES 3 and 4 are sectional views illustrating the process for assembling the panel shown in FIGURE 2 in its form prior to assembly;

FIGURE 5 is a sectional view illustrating another conventional process for producing a plasma display panel;

FIGURE 6 is a schematic diagram of an evacuating and gas introducing apparatus which can be used for carrying out this invention;

FIGURE 7 is a top plan view of a plasma display panel embodying this invention;

FIGURES 8 to 10 are sectional views taken along the line B-B of FIGURE 7 and illustrating a series of steps of a process embodying this invention;

FIGURES 11 to 14 are view illustrating a process according to another embodiment of this invention;

FIGURES 15 and 16 are views illustrating a process according to still another embodiment of this invention; and

FIGURES 17 to 19 are views illustrating a process according to a further embodiment of this invention.

result, the softened material 27 spreads only to an area which is slightly larger in diameter than the port 2, as shown in FIGURE 10 or 14. As the port 2 is usually formed by drilling, however, it is often the case that the back panel member 1 has a roughened surface around the port 2. If it is too rough, the blocking material 27 as shown in FIGURE 10 or 14 fails to make a complete seal against the leakage of the discharge gas. In this connection, it is desirable to cause the softened blocking material to spread to a greater extent into the space defined between the back and front panel members 1 and 3 and thereby form a gas-tight seal on a smooth surface.

Another modification of the process according to this invention is, therefore, shown in FIGURES 15 and 16. This modification is characterized by employing a blocking member in the form of a tablet 28 carried on the inner surface of a front panel member 3 and having a diameter which is larger than that of a gas port 2, and a thickness which is equal to, or larger than, the height of insulating partitions 5, as shown in FIGURE 15. Two panel members 1 and 3 are put together in the vacuum tank 21. The vacuum tank 21 is evacuated and the panel members 1 and 3 are degassed by heating at a temperature of about 350° C. At this level of temperature, glass 6 remains hard and keeps the back and front panel members 1 and 3 at the initial distance from each other. As the insulating partitions 5 are still spaced apart from the back panel member 1, the enclosure defined between the panel members 1 and 3 has a higher conductance and can be degassed and evacuated more efficiently than when the partitions 5 contact the back panel member 1. When a vacuum degree of  $10^{-7}$  torr has been reached, the evacuation is discontinued and a discharge gas is introduced into the tank 21 to fill the enclosure.

Then, the temperature is raised to 450° C to soften the glass 6. The softened glass 6 is deformed or flattened by the weight of the back panel member 1 or an external force applied to it, and the back and front panel members 1 and 3 have a smaller distance therebetween. This means a reduction in volume of the enclosure which would bring about an elevation in pressure of the discharge gas in the enclosure if it were closed. The port 2, however, remains open to allow the discharge gas to maintain a balance of pressure between the inside and outside of the enclosure until the back panel member 1 contacts the blocking tablet 28.

The softened glass 6 is eventually deformed until the back panel member 1 contacts the tablet 28. The tablet 28 is also softened by exposure to the temperature of 450° C and the softened tablet 28 intimately contacts the back panel member 1

and closes the port 2, as shown in FIGURE 16. The closed port 2 shuts off the flow of the discharge gas between the inside and outside of the enclosure and the back and front panel members 1 and 3 cease to reduce their distance. If the tank 21 as a whole is, then, cooled, the glass 6 and the tablet 28 solidify in their respective shapes as shown in FIGURE 16. If it has been cooled to normal temperature, the assembly which has been made is removed from the tank 21 to yield a plasma display panel filled with the discharge gas.

Still another modification is shown in FIGURES 17 to 19. This process is characterized by employing a blocking member which comprises a combination of a blocking rod 27 similar to that shown in FIGURES 7 to 10 and a blocking tablet 28. The tablet 28 is similar to its counterpart shown in FIGURE 15 in that it has a diameter which is larger than that of a gas port 2, but differs from it in that the tablet 28 shown in FIGURE 17 or 18 has a thickness which is smaller than the height of insulating partitions 5.

The tablet 28 may be a disk having a diameter of about 8 mm and a thickness of about 0.1 mm if the dimensions of the other parts and materials of a panel are as hereinbefore mentioned by way of example with reference to FIGURES 7 to 10. The tablet 28 may be formed on a front panel member 3 by printing, or otherwise. Two panel members 1 and 3 are put together in the vacuum tank 21. A discharge gas is introduced into the tank 21 to fill the enclosure defined between the two panel members 1 and 3, as shown in FIGURE 18, while the whole is heated to a temperature of 350° C. Then, the temperature is raised to 460° C to soften the rod 27 and the tablet 28, which are of the same material, so that the softened material may form a unitary mass. The softened material of the rod 27 is drawn toward the softened tablet 28 by its surface tension to close the port 2 and fill the gap existing between the back panel member 1 and the tablet 28, as shown in FIGURE 19.

Referring again to FIGURES 15 and 16, it is effective to shape the blocking tablet 28 like a ring to ensure that no excess of the softened material of the tablet 28 overflow the port 2.

Although the port 2 has been described and shown as being formed in the back panel member 1, the same results of this invention can be achieved, even if it may be formed in the front panel member 3. Although the foregoing description and the drawings have been limited to the case in which only one port 2 is provided, it will sometimes be necessary or desirable to provide more than one port 2. This is particularly the case when a large plasma display panel is made. A larger enclosure defined between two panel members has a lower conductance and is more difficult

at least one blocking member having a melting point which is higher than that of said sealing material formed in an appropriate positional relation to said port;

placing said first and second panel members in a parallel and spaced apart relation to each other, so that said sealing material may contact the other of said panel members and define a gas-tight enclosure between said panel members, while said blocking member is positioned in said enclosure and extends through said port;

evacuating said enclosure through said port;

filling said enclosure with a discharge gas through said port; and

heating the whole to soften said sealing material so that said softened material may join said panel members along the edges thereof and form a gas-tight seal therebetween, while softening said blocking member so that said softened member may form a gas-tight closure of said port.

7. A process for producing a plasma display panel comprising the steps of:

preparing a first panel member and a transparent second panel member, one of said panel members carrying a sealing material along its edge, one of said panel members having at least one port formed therethrough, while the other of said panel members carries at least one blocking member formed in an appropriate positional relation to said port and having a height which is smaller than said sealing material, and which is larger than the prospective final distance between said two panel members;

placing said first and second panel members in a parallel and spaced apart relation to each other, so that said sealing material may contact the other of said panel members and define a gas-tight enclosure between said panel members, while said blocking member faces said port and stays within said enclosure;

evacuating said enclosure through said port;

filling said enclosure with a discharge gas through said port;

heating the whole to soften said sealing material so that said softened material may join said panel members along the edges thereof and form a gas-tight seal therebetween;

while softening said blocking member so that said softened member may form a gas-tight closure of said port.

FIG. 1

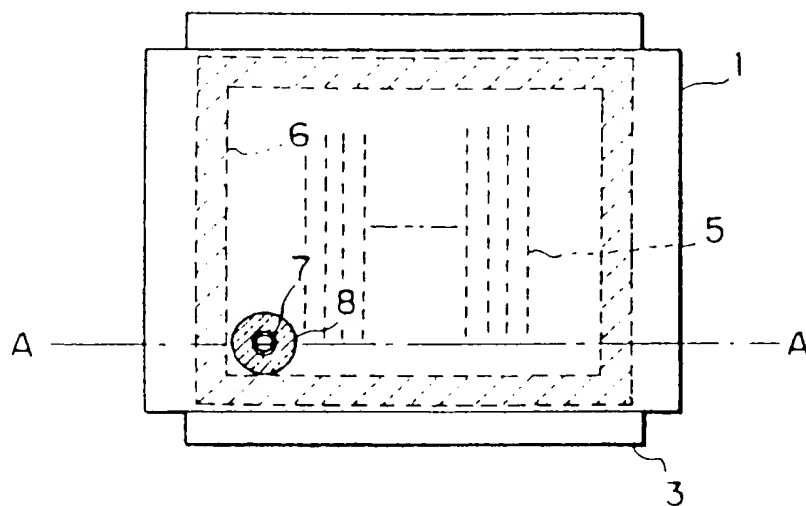


FIG. 2

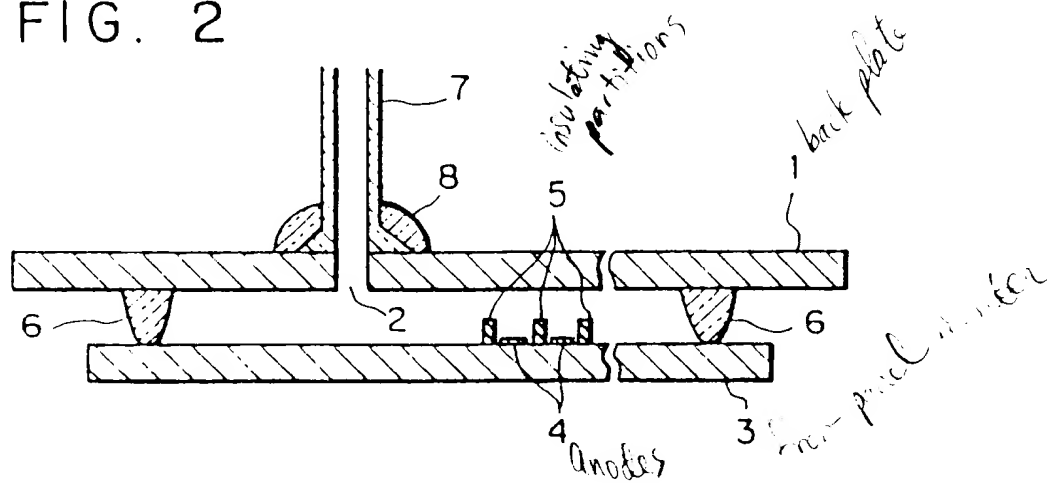


FIG. 3

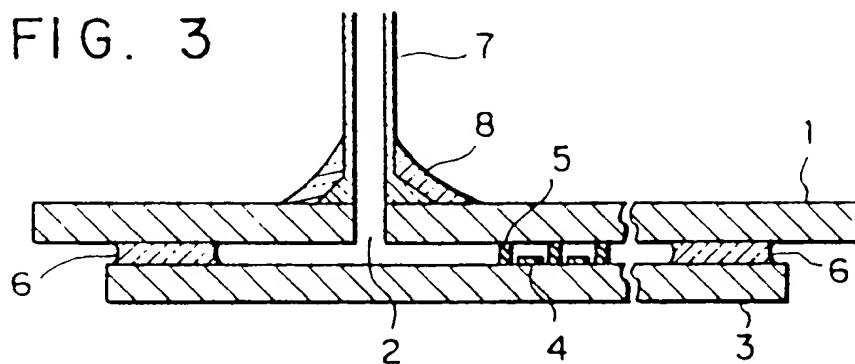


FIG. 4

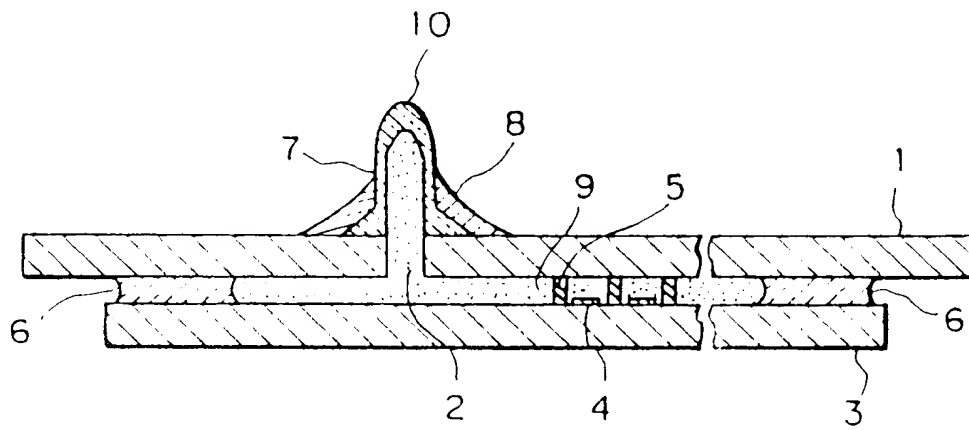


FIG. 5

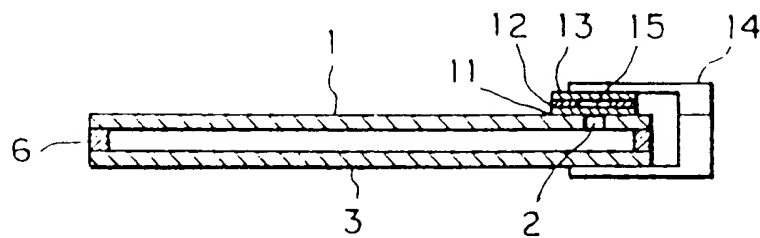


FIG. 6

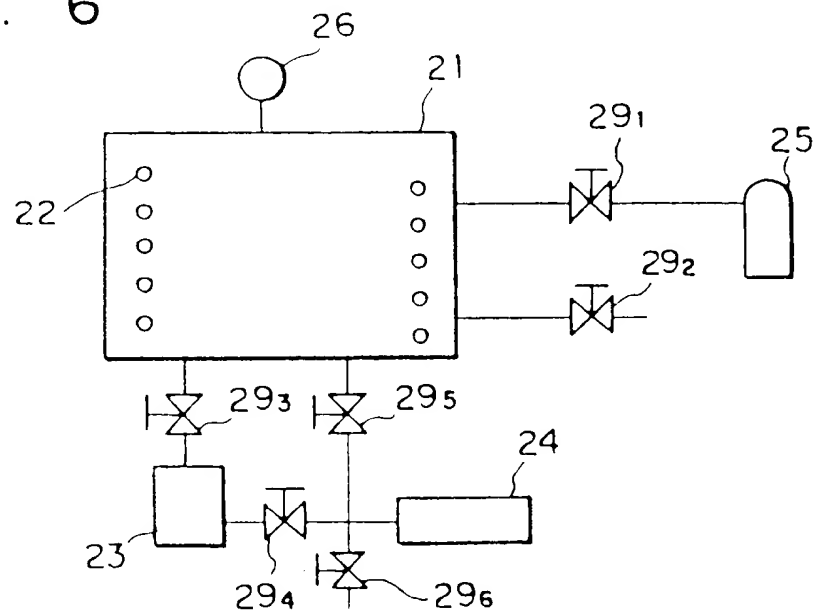


FIG. 7

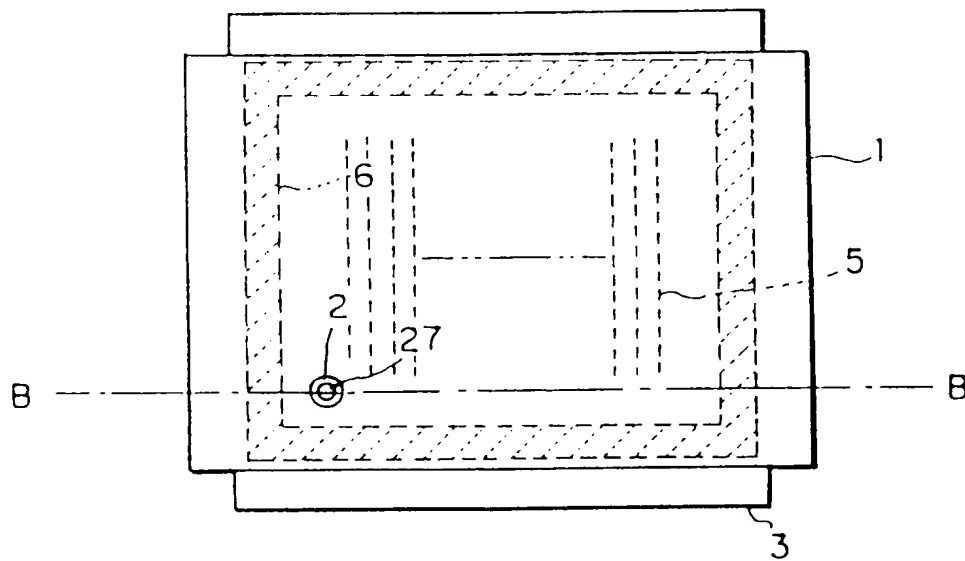


FIG. 8

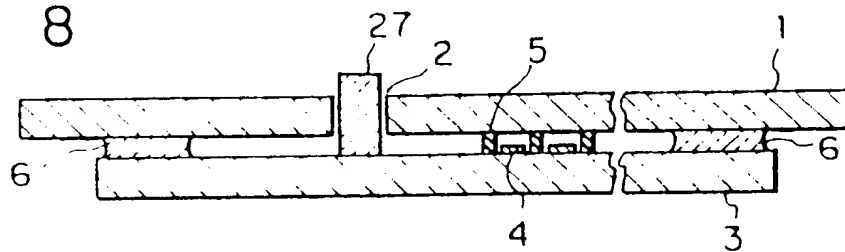


FIG. 9

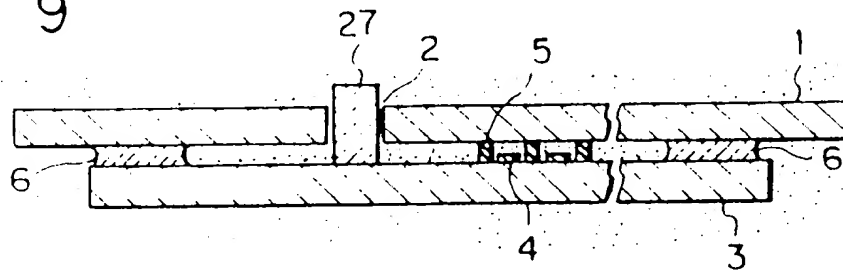


FIG. 10

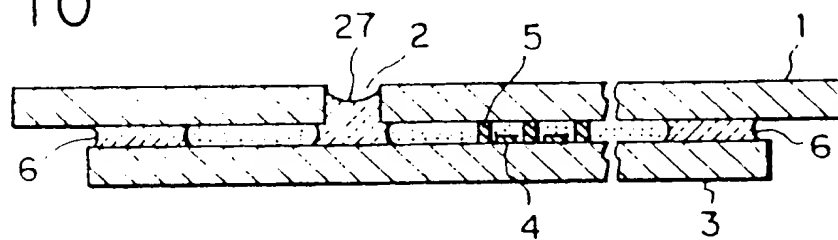


FIG. 11

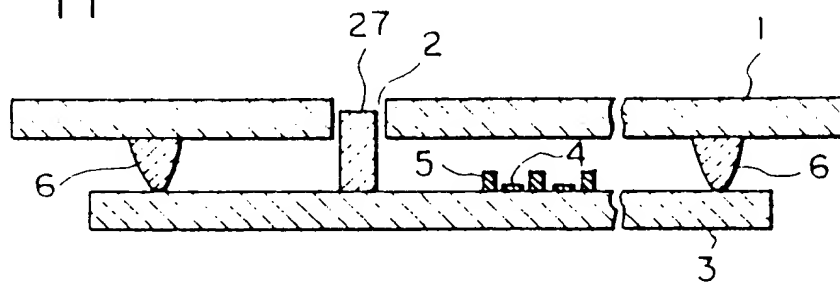


FIG. 12

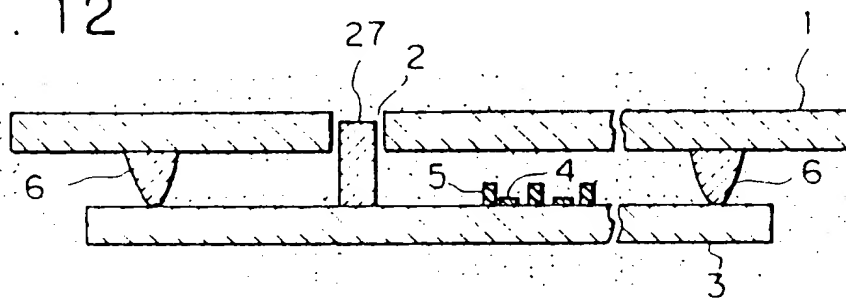


FIG. 13

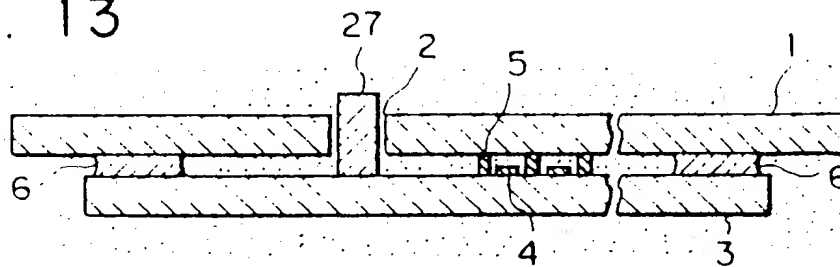


FIG. 14

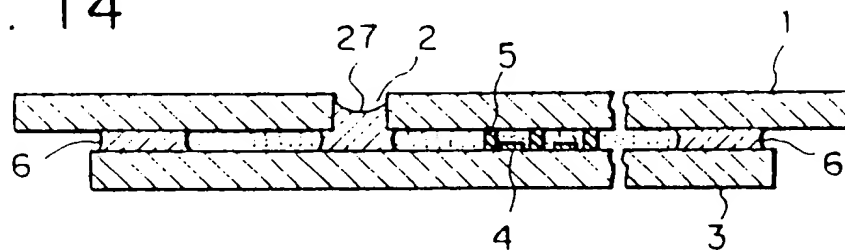


FIG. 15

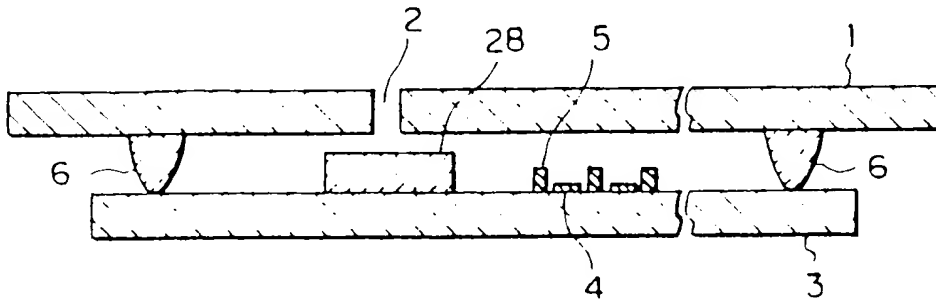


FIG. 16

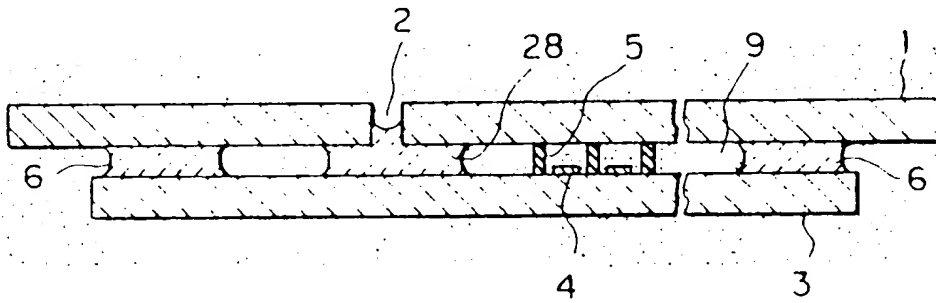


FIG. 17

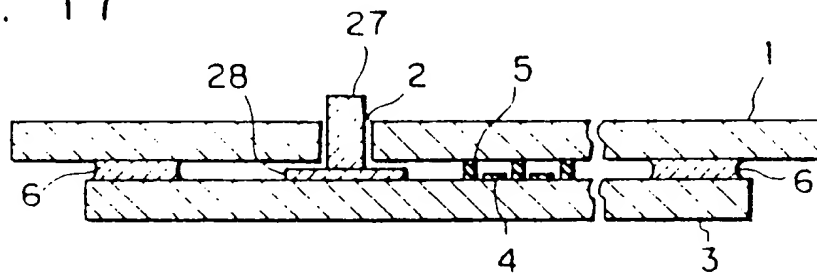


FIG. 18

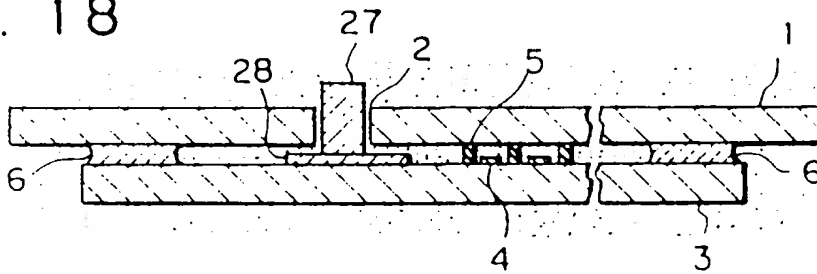
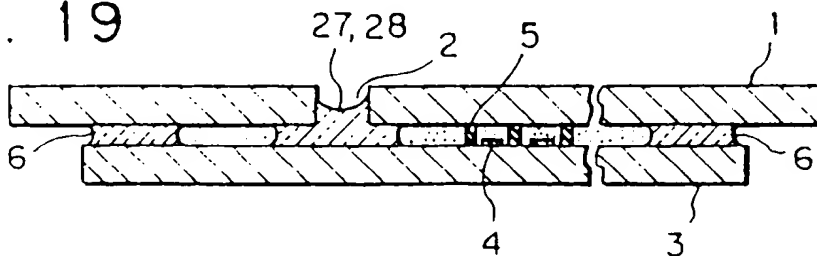


FIG. 19





- 2 - \* -

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(71) Applicant: MITSUBISHI DENKI KABUSHIKI  
KAISHA  
2-3, Marunouchi 2-chome Chiyoda-ku  
Tokyo 100(JP)

(72) Inventor: Nagano, Shinichirou, c/o Mitsubishi  
Denki K.K.  
Comm. Equipment Works, 1-1 Tsukaguchi  
Honmachi 8-chome, Amagasaki-shi,  
Hyogo(JP)  
Inventor: Yamanaka, Takashi, c/o Mitsubishi  
Denki K.K.  
Comm. Equipment Works, 1-1 Tsukaguchi  
Honmachi 8-chome, Amagasaki-shi,  
Hyogo(JP)  
Inventor: Uchiyama, Osamu, c/o Mitsubishi  
Denki K.K.  
Comm. Equipment Works, 1-1 Tsukaguchi  
Honmachi 8-chome, Amagasaki-shi,  
Hyogo(JP)

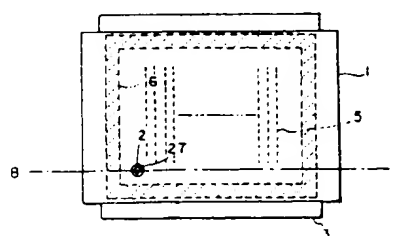
(74) Representative: Eisenführ, Speiser & Strasse  
Martinistrasse 24  
W-2800 Bremen 1(DE)

(54) Plasma display panel and a process for producing the same.

(57) An enclosure defined between two panel members is filled with a discharge gas. One of the panel members carries a sealing material (6) surrounding the enclosure and has an evacuating and gas-filling port (2), while the other panel member carries a port blocking member (27) formed in an appropriate positional relation to the port. The whole is heated, so that the sealing material may soften and join the panel members to each other along the edges thereof and form a gas-tight seal therebetween, while the blocking member also softens to close the port. The softened blocking member stays within the enclosure and the port. Nothing projects from either of the panel members at any angle thereto. A strong plasma display panel having only a minimum thickness as required can, therefore, be realized. If the joining

of the panel members and the closing of the port are simultaneously carried out, the panel can be made quickly and at a low cost. The closing of the port can alternatively be done after the joining of the panel members.

FIG. 7





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-3 914 000 (MARTIN BECKERMAN ET AL) * abstract; claim 1; figures 3-5 *** column 3, line 6 - column 4, line 28 ** - - - -	1,2,5-7	H 01 J 9/26 H 01 J 17/49
A	US-A-4 182 540 (ROGER A. FRANKLAND, HENRY E. FRANKLIN) * abstract; figures *** column 1, line 58 - column 2, line 28 * - - - -	1,2,5-7	
A	EP-A-0 031 921 (SIEMENS AKTIENGESELLSCHAFT) * abstract; figures 2-4,6 *** page 6, line 12 - page 6, line 16 * ** page 7, line 27 - page 8, line 3 *** page 9, line 2 - page 9, line 6 ** - - - -	1,2,5-7	
A	IBM TECHNICAL DISCLOSURE BULLETIN vol. 24, no. 7B, December 1981, pages 3899 - 3900; J.B.SHAPIRO: 'Multiple Processed, Tubeless Gas Display Panels' * Whole Document** - - - -	3-5	
A	US-A-4 029 371 (GEORGE A. KUPSKY) * abstract; figures 5,7,8 *** column 6, line 13 - column 6, line 23 ** - - - -	1,2	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	IBM TECHNICAL DISCLOSURE BULLETIN vol. 28, no. 7, December 1985, pages 2774 - 2776; 'Addition of Weight-Absorbing Modules To Quad Seal Fixtures.' * Whole Document** - - - - -	6,7	H 01 J
The present search report has been drawn up for all claims			
Place of search		Date of completion of search	Examiner
The Hague		17 January 92	CLARKE N.S.
<b>CATEGORY OF CITED DOCUMENTS</b> X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons &: member of the same patent family, corresponding document			